Aquatic Mammals 1998, **24.2**, 123–132

Baiji (*Lipotes vexillifer*) in the lower Yangtze River: movements, numbers threats and conservation needs

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Abstract

Five boat surveys were conducted along a 500 km section of the Yangtze River between Zhenjiang and Hukou in 1989–1991. Seven individual baiji were photographically identified in 84 photographs based on natural markings. There were 7 sightings of baiji in May 1989, 4 sightings in March 1990 and 6 sightings in April–May 1990, resulting in total counts of 9, 7 and 11 individuals respectively. Photographic identifications and sighting records showed that baiji groups made both local and long-range movements. The largest recorded range of a recognizable baiji was 200+ km from the initial sighting location. Estimated population size was about 30 individuals in the 500 km river study area. If baiji still inhabits its historical 1700 km range in the Yangtze River, and population density is similar throughout this habitat section, there may only be 100 baiji remaining in the river. Concentration of manpower and resources to speed up the completion of semi-natural reserve projects are urgently needed if baiji are to survive beyond the start of the 21st century.

Resumen

Cinco censos en bote fueron conducidos a lo largo de una sección de 500 km del rio Yangtze, entre Zhenjiang y Hukou, de 1989 a 1991. Siete diferente individuos del baiji fueron identificados en 84 fotografías mediante la descripción de marcas naturales. Se realizaron 7 avistamientos del baiji en mayo de 1989, 4 avistamientos en marzo de 1990 y 6 avistamientos en abril y mayo de 1990, resultando en un conteo de 9, 7 y, 11 individuos respectivamente. Los avistamientos y las identificaciones mediante fotographia indican que los grupos realizaron tanto movemientos restringidos como grandes desplazaminetos. La distancia más larga recorrida por uno de los siete baiji identificados fue de más de 200 km a partir del lugar donde fue fotografiado. El tamaño de la población en la sección de 500 km estudiada se estimó en cerca de 30 individuos. Si se asume que el baiji todavia reside a lo largo de la habitable region de 1700 km del rio, y que la densidad de la población es la misma en toda esa región, solamente 100 individuos del baiji parecen habitar el rio Yangtze. La concentración de recursos humanos y financieros para acelerar proyectos de reservas semi-naturales es indispensable si el baiji va a sobrevivir más allá del inicio del siglo 21.

Introduction

The Chinese river dolphin, or baiji (*Lipotes vexillifer*), is a relict species of the Yangtze River, belonging to the monotypic family Lipotidae (Zhou *et al.*, 1979*a*). Its numbers have recently decreased, apparently due to fisheries entanglements and general habitat degradation (Perrin *et al.*, 1989, Zhou, 1989*a*). It is now considered critically endangered (Zhou, 1992; Zhou *et al.*, 1995) and is included in the IUCN list of threatened animals (Baillie & Groombridge, 1996). Although a number of boat-based surveys have been conducted in the middle and lower reaches of the Yangtze River since 1979, firm population estimates have not been made (Zhou *et al.*, 1979*b*, 1982; Zhou, 1982, 1986, Chen *et al.*, 1980, 1985; Lin *et al.*, 1985, Chen & Hua, 1989; Hua *et al.*, 1989; Zhou & Li, 1989).

This paper combines information from surveys and photographic 'mark-recapture' methodology to re-assess the population size and to describe general movement pattern information, useful for assessment of the species. It also summarizes likely reasons for baiji decline and presents recommendations for conservation action.

Methods

Surveys

Five boat surveys were conducted along a 500 km section of the Yangtze River, between Zhenjiang in

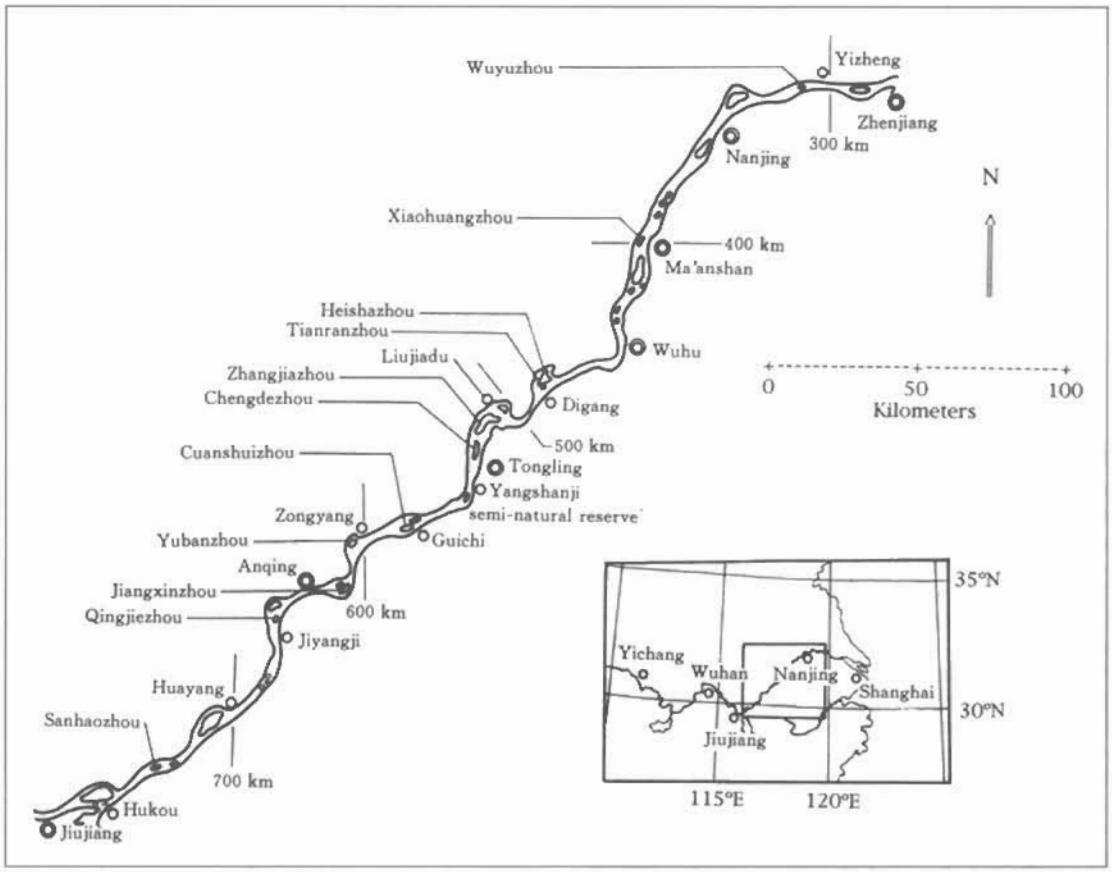

Figure 1. Map of the study area in the lower reaches of the Yangtze River.

the northeast (32°2′N, 119°4′E) and Hukou in the southwest (29°7′N, 116°2′E) in 1989, 1990 and 1991 (Fig. 1). We used four to eight 7 m fishing boats with outboard engines of 4–12 Hp, with two trained fishermen operators/observers on each boat, and researchers on some vessels. Boats were spread out 100–200 m in side-by-side formation to maximize study area coverage, and travelled at 7–8 km/hr. Vessels were in contact by radios and signal flags, and surveys were interrupted to observe and photograph encountered baiji. Photographs were taken with 100 ISO color print film in a 35 mm Canon camera equipped with 300 mm telephoto lens. Individual identifications were based on body scratches, dorsal fin nicks and deformities, and facial pigment patterns (Würsig & Würsig, 1977; Würsig & Jefferson, 1990). Depth of water was measured by Skipper ED-162 echosounder and data were recorded on current speed, water visibility, air and water temperature, river bank characteristics, and types and numbers of fishing gear. Specimens of fish were identified when available at places where baiji were sighted. Birds on the river surface and bank were also recorded.

Prior to the five surveys here, one author of this study (Jiang Sun) made observations and photo-identifications of baiji in the Yubanzhou section (Fig. 1), from 8 March–23 April 1989; these data are included here and are used for population estimates. Percentage of identifiable animals was calculated by dividing total number of identifications by total number of dolphins seen in a survey, and averaging that proportion for all surveys for which photo-identifications were attempted (May 1989 and March–May 1990; poor weather precluded identifications in March and November–December 1991).

Population size was estimated by dividing number of identifiable animals by percentage of identifiable animals. Two methods were employed to calculate number of identifiable animals (S).

(1) According to the principles of probability, number of identifiable animals was calculated by resolving the following equations:

Table 1. Efforts and counts of baiji in the 1989–1991 survey seasons in the lower Yangtze River

Date	Section	Section length (km)	Survey distance (km)	Survey time (h)	Baiji counted[1]
3–26 May 1989	Nanjing–Huangshiji	330	892	116	9
4–31 March 1990	Nanjing–Hukou	420	1030	164	7
22 April–18 May 1990	Zhenjiang–Hukou	500	1105	144	11
13–23 March 1991	Nanjing–Hukou	420	642	87	0
23 November–21 December 1991	Zhenjiang–Hukon	500	1094	151	2

[1]Repeated counts were subtracted according to identification photographs.

$$SQ_1 = D_1 \quad [1\text{-}1]$$

$$SQ_2 = D_2 \quad [1\text{-}2]$$

$$SQ_1Q_2 = D_{12} \quad [1\text{-}3]$$

where: S=number of identifiable animals; Q_1=probability of identification for March–May 1989; Q_2=probability of identification for March–May 1990; D_1=number of animals identified during the survey in March–May 1989; D_2=number of animals identified during the survey in March–May 1990; and D_{12}=number of animals identified both in March–May 1989 and March–May 1990.

(2) Number of identifiable animals were calculated according to Chapman's modified Peterson estimate, as recommended by Hammond (1986):

$$S = (D_1+1)(D_2+1)/(D_{12}+1) \quad [2]$$

Population size (N) was also estimated by the mark-recapture model:

$$N/M = n/m \quad [3]$$

where: N=population size; M=number of marked animals (animals identified in March–May 1989); n=number of recaptured animals (number of individual*times sighted in March–May 1990); and m=number of marked animals within total number recaptured (number of individual*times identified in both March–May 1989 and March–May 1990).

Results

The five surveys covered 4763 km in 662 h. The three field trips in Spring 1989 and 1990 yielded good results; the two trips in 1991 were compromised by poor weather (Table 1).

Distribution

Sightings of baiji were made at Wuyuzhou (310 km, all listed distances are from Wusongkou (31°4′N, 121°5′E), about 100 km from the mouth of the Yangtze River at Shanghai), Xiaohuangzhou (400 km), Tianranzhou (475–490 km), Chengdezhou (540 km), Yangshaniji (550 km), Cuanshuizhou (590 km), Yubanzhou (600–603 km), Jiangxinzhou (Anqing, 640 km), Jiyangji (670 km) and Sanhaozhou (740–747 km).

Photo-identification

A total of 1178 photographs of baiji were taken, and seven individual baiji were identified in 84 photographs (Table 2). Six were identified in 1989 and three in 1990. Three dolphins were sighted more than once (Fig. 2), and two (#001 and #003) were seen three times. Times between sightings of #001 were 373 and 3 days, and of #003 were 10 and 344 days. The inter-year matches between 1989 and 1990 indicate that scrape and dorsal fin notch patterns can last for at least 1 year. The third re-sighted dolphin was #007, seen 15 days after a previous sighting. Sizes of groups with recognizable individuals ranged from 1–6, at a mean of 3.4 ± 1.50 S.D. (n=11 dolphins) (Table 2).

Abundance

Twelve baiji were seen during seven sightings in the May 1989 survey. Three repeat sightings were subtracted, resulting in a total count of nine dolphins. Thirteen individuals were seen during four sightings in the March 1990 survey, while four of them were identifiable. Two sightings were subtracted due to photographic evidence of repeats, resulting in a total count of seven animals, two identifiable (Table 2), for March 1990. In April–May 1990, 30 individuals were sighted on six occasions, four of them identifiable. Three repeat sightings with 19 baiji were subtracted, resulting in a total count of 11 animals with one identifiable (Table 2). Therefore, we had eight individual*times of identifiable animals ($=m$) in 43 counts ($=n$ in [3]) during the March–May 1990 season which was regarded as the recapture phase. In 1991, only two baiji were sighted on one occasion, in November (Table 1).

Six baiji were identified by their natural markings in March–May 1989 ($=D_1$ in [1-1] to [1-3] and [2], =M in [3]). Three were identified in 1990 (two in March and one in April–May, $=D_2$), while two of them were identified both in 1989 and 1990 seasons

Table 2. Distinctive feature of the identified individuals and number of associated individuals counted. Dates are in parentheses

ID #	Number of photographs	Distinctive features	Group sizes (and dates) of groups with recognizable individuals	
			1989	1990
001	36	Arched scrape on left side of back in front of dorsal fin	6 (9/3)	3 (17/3) 3 (20/3)
002	2	Arched scrape on right side of back in front of dorsal fin	? (29/3)	
003	11	Notch on posterior edge of dorsal fin	4 (4/5) 1 (14/5)	5 (24/4)
004	4	Two parallel straight scrapes from mid-back to shoulder on right side of back	4 (4/5)	
005	8	Facial pigment pattern	1 (17/5)	
006	2	Snout obviously bows upward	3 (18/5)	
007	21	Anterior half of dorsal fin absent	3 (14/3) 4 (29/3)	

(D_{12}=2, Table 2). The number of identifiable animals was calculated to be nine according to [1-1] to [1-3] and [3]. The percentage of identifiable animals in the total count was 29%. Consequently, the population size for the baiji in the study area was estimated to be 31. In the estimate according to [3], the population size for baiji in this river section between Zhenjiang and Hukou was 32. If individuals exchange between the investigated section and other areas, 31 or 32 may be an over-estimate.

Movement

Case history ID #001. Six baiji were sighted on 9 March 1989 in the Yubanzhou river section, which is about 600 km from Wusongkou, and #001 was identified. The animal was recognized again by photographs taken on 17 March 1990 in the Jiangxinzhou (Anqing) river section, which is about 640 km from Wusongkou. It was then in a group of two adults and one subadult. The animals moved steadily in an upstream direction and were followed by the research team for 9 h 50 min. Observations were terminated at 5:30 p.m. when the animals reached the Jiyangji river section 30 km upstream of Anqing. The group (also with two adults and one subadult, but not definitely the same individuals as on 17 March) was sighted again on 20 March at Zhoujiawan, which is about 740 km from Wusongkou. It had moved 100 km upriver in 3 days, at an average travel speed of about 33 km per day. On 20 March, the animals swam upstream and downstream and fed on fish within a range of about 7 km between Zhoujiawan and Yijiazhou in the Sanhaozhou river section, and were followed for 6 h 20 min. The distance is 107 km from Yijiazhou (20 March) to Jiangxinzhou (17 March); and is 147 km between Yijiazhou and Yubanzhou, where #001 was photographed in 1989.

Case history ID #003. This baiji was first sighted and photographed on 4 May 1989, upstream of Tianranzhou. It was in a group of five, and photographs of one of its partners, #004, were also taken on the same day. The group travelled 15 km downstream in the afternoon, passed through the channel between Heishazhou and Tianranzhou to downstream of the latter, and was followed by the research team for 5 h 30 min. Ten days later, #003 was photographed again at the Xiaohuangzhou river section, 75 km downstream of the previous sighting. This time the animal was alone. The baiji #003 was sighted again with four others on 24 April 1990, at the Yubanzhou rive section. The 1990 locality is over 200 km upstream from the 14 May 1989 locality. This represents the largest recorded distance of movement of an individual baiji.

Animals #002 and #007 (along with single sightings of #001 and #003) were sighted in the Yubanzhou area, about 600 km from Wusongkou. Number #004 was sighted near Tianranzhou (about 480 km from Wusongkou), #005 at Yangshanji (550 km) and #006 at Cuanshuizhou (590 km).

Relationship with finless porpoises

Occasionally, baiji and finless porpoises (*Neophocaena phocaenoides*) groups appeared to feed together for short times. On 17 March 1990, 4 finless porpoises were found feeding together with three baiji in the Anqing section (Fig. 3, 648 km from Wusongkou). The two groups mixed for about 1 h between 8:30 a.m. and 9:30 a.m. A number of black-headed gulls (*Larus ridibundus*) were found feeding in the same locality. Again on

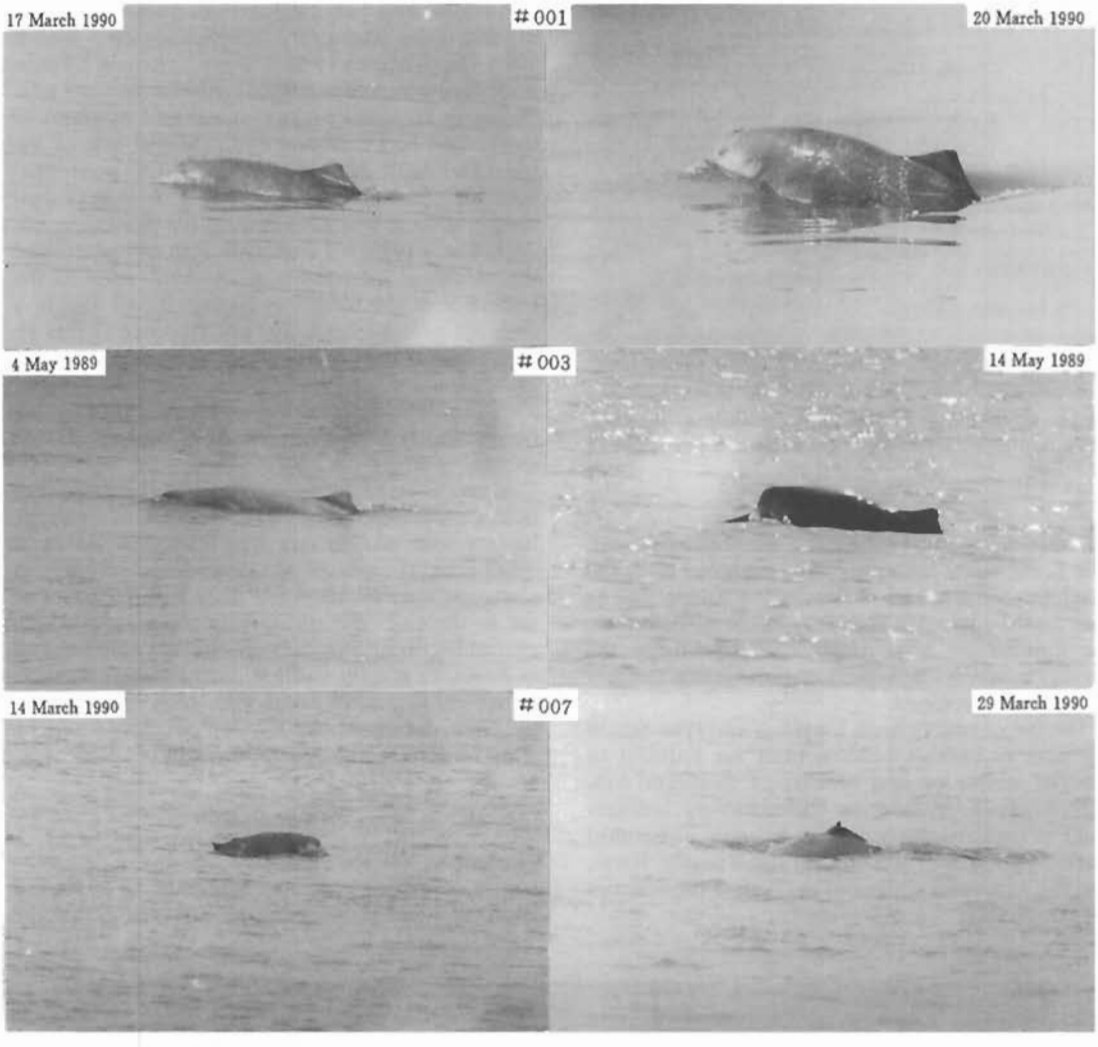

Figure 2. Three individual baiji followed photographically through time.

17 March 1990, apparently the same baiji group was found feeding with a group of five finless porpoises from 3:15–3:45 p.m. in the Qingjiezhou section (664 km from Wusongkou). On 20 March 1990, the apparently same baiji group was found mixed with four finless porpoises at 11:30 a.m. for 20 min, and at 4:30 p.m. for 1 h. A further record was obtained in the afternoon of 14 March 1990, when two baiji and three finless porpoises fed together at 3 p.m., near Tanjiagou (596 km from Wusongkou) in the Yubanzhou river section.

Fisheries and incidental killings in fisheries

Several fishing methods are used in the lower Yangtze. They include gillnetting, trapping (fyke nets), longlining and lift net fishing, (Table 3). Crab net boats are operated mainly in autumn and winter, fry netting is carried out exclusively in spring, while other fishing gear is used year round, with a tendency to increase in spring. Freshwater gillnets in the lower Yangtze vary in structure, mesh size, operating period and target species. Fyke nets are set in shallow water along the river bank. Fyke netting increases in spring because fish become more active at a warmer water temperature, resulting in a greater number swimming closer to the river bank; the increase of gillnetting in spring is related to the arrival of the migratory long-tailed herring (*Coilia ectenes*). Rolling hook longlines are anchored on the river bottom with stones, and

Figure 3. Baiji and finless porpoise feeding together. Black-headed gulls feeding in the same spot. Photograph by J. Sun.

operated by two fishermen in a small fishing boat. The hook boats return to river branches after the longlines are set, and return to the fishing site to pick up the entangled fish every 12–24 h. Therefore, the number or hook boats counted during the surveys is only a small fraction of the actual number of longlines deployed.

The use of rolling hook longlines and fyke nets in the river is banned because both are harmful to fisheries resources, and because of incidental killings of baiji in the fisheries. Unfortunately, enforcement of regulations concerning banning of harmful fishing gear is very difficult on the Yangtze River, and the incidental killings of the baiji in the fisheries are continuing.

An adult baiji bearing dozens of hooks was found drifting down river near Chengdezhou on 5 March 1990. On 14 March 1990, a lactating female 2.4 m in body length was found drifting down the river near Jingjiang, Jiangsu Province. It was held by about 30 hooks and had a wound at the lateral side of the tail. The right half of the fluke was perforated with a hole 3 mm in diameter. The animal died shortly after it was retrieved by the fishermen. On 25 January 1992, a 1.8 m male with a rope around mid-length of the body and four hook scars on the underside of the fluke was entangled and died in a crab net near Yizheng, Jiangsu Province (Table 4). Carcasses of baiji found on 3 September 1992, 26 November 1993, 4 November 1994 and 15 January 1996 (Table 4) were not entangled by nets or rolling hooks, and were possibly killed by shocks of electric fishing.

In recent years, the use of electric fishing gear has been increasing. Such gear is composed of a storage battery and transformer which are carried by a small boat. A high voltage is produced between an electrode lowered from the boat and another one set in the river during operation. Electric fishing gear indiscriminately destroys fishery resources and is therefore strictly banned by the fishery agency. However, the small boats that carry this type of gear hide during the day in small channels along the Yangtze River, and operate at night.

Discussion

Movement

Lin *et al.* (1985) suggested that each river section was usually inhabited by a baiji group, and that the

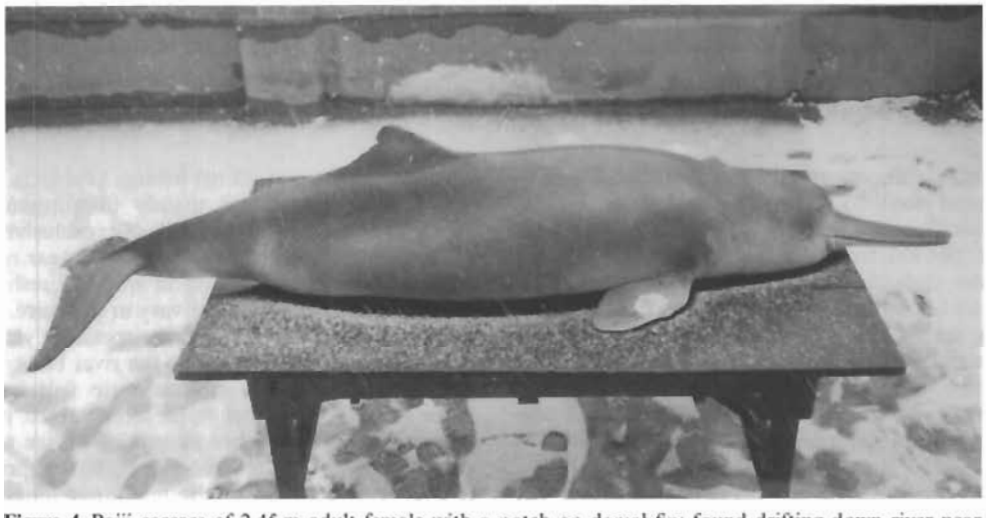

Figure 4. Baiji carcass of 2.45 m adult female with a notch on dorsal fin; found drifting down river near Jiangyin on 15 January 1996.

Table 3. Type and number of fishing gear counted in the study area in 1989–1991 survey seasons in the lower Yangtze

	1989 May	1990 May	1990 Apr–Mar	1991 May	1991 Nov–Dec
Fyke net	755	478	1948	118	523
Stationary lift net	150	103	186	14	14
Boat lift net	59	80	81	46	24
Rolling hook boat	45	107	80	6	6
Gillnet boat	217	73	221	—	4
Crab net boat	—	20	—	—	168
Fry net	31	—	12	—	—

Table 4. Records of dead or injured baiji found in the lower Yangtze in 1989–1996

Date	River section	Dead or injured baiji	Witness
April 1989	Between Wuhu and Nanjing	Carcass drifting down river	Shuguang Fishing Team fisherman
5 March 1990	Downstream of Chengdezhou	Adult bearing dozens of hooks, drifting down river	Sun Daqin
14 March 1990	Jingjiang	2.4 m lactating female held by about 30 hooks, drifting down river	Present authors
20 June 1990	Zhangjiazhou	Carcass of young baiji stranded on sand bar	Chen Ruyou
27 July 1990	Digang	Carcass with 2 propeller wounds	Zhang Chunyou
July 1990	Liujiadu	Carcass stranded on north bank	Zhang Xuemin
August 1990	Huayang	Carcass drifting down river	Local fisherman
9 December 1991	Chengdezhou	Carcass decayed	Zhang Xiuying
25 January 1992	Yizheng	1.8 m male with 4 hook cuts on the underside of fluke, drowned in crab net	Present authors
3 September 1992	Yubanzhou	Carcass of 1.1 m male juvenile, drifting down river	Present authors
26 November 1993	Taixing	Carcass of 2.41 m pregnant female, drifting down river	Present authors
4 November 1994	Ma'anshan	Carcass of 2.40 m adult female, drifting down river	Present authors
15 January 1996	Jiangyin	Carcass of 2.45 m adult female with a notch on dorsal fin, drifting down river (Fig. 4)	Present authors

group was confined to that river section. However, according to the present study, it is unlikely that individual baiji groups are so confined. Photographic identifications and sighting records showed that some individuals made both local and long-range movements. Local movement has been observed in the Cuanshuizhou–Yubanzhou section, which was a favorite site for baiji in the lower Yangtze. In 1990, a group of 3–4 animals was sighted in the section on 14 March when the research team passed up river and again on 29 March when the team passed down river; a group of seven was seen on 24–25 April when the team passed up river and on 3–4 May when the team passed down river. It seems that the latter was probably a temporary aggregation formed by the joining of the new arrivals with the former. These animals swam within a range of about 10 km. However, the travel made by #001 and its group in March 1990 was clearly an example of long-range movement, covering a distance of 100 km in 3 days. The largest recorded range of a recognized baiji was over 200 km from the initial sighting location (#003).

Population status

On the basis of the data obtained during six expeditions in the lower Yangtze from 1979 through 1981, Zhou and colleagues estimated about 30–60 individuals in a 250 km stretch of the lower Yangtze, which is 350–600 km from Wusongkou (Zhou, 1982; Zhou *et al.*, 1979*b*, 1982). Lin *et al.* (1985) made nine expeditions between 1978 and 1983 and obtained a count of 29 individuals in a 270 km stretch (370–640 km from Wusongkou), almost identical with that reported by Zhou and colleagues; or 47 individuals in a 458 km section (330–788 km from Wusongkou), geographically similar to the present study. Chen & Hua (1989) made two surveys in 1985–1986; they counted

26 animals in the 350–602 km section, or 82 animals in the 278–772 km section, and estimated the total population at approximately 300 individuals. A comparison between the earlier data and the present results indicates that about half of the animals have disappeared in the 500 km stretch of river in the past 10 years. According to the present study, the population density in the study area was about one per 17.1 km, or 0.059 per km. If we assume that baiji inhabit the 1700 km river stretch they used to, and that the population density is similar throughout the inhabited section, then only about 100 individuals may be left in the Yangtze River (see also Zhou *et al.*, 1995). Unfortunately, there is no indication that baiji are more numerous in other parts of the river, near Wuhan for example (Chen &Hua, 1989; Chen Peixun, pers. comm.), and it appears that the overall population size is less than the minimum requirement for a viable population. The baiji may be very close to extinction.

Habitat degradation

The Yangtze River is one of the chief river systems of the world, next only to the Nile and the Amazon in length. It is the cradle of Chinese civilization; nearly one-third of the population of China or almost 10% of the entire world population lives along the Yangtze valley. It is no wonder that as the major waterway into China, the Yangtze is suffering massive habitat degradation. Up to 1949, approximately 500 domestic and foreign vessels operated on the river. Large-scale economic development along the Yangtze valley started in the 1950s, and the threats to the baiji thereafter have been discussed thoroughly (Zhou, 1982, 1989*b*; Zhou & Li, 1989; Lin *et al.*, 1985; Chen & Hua, 1989).

Unfortunately, the major threats besides fishing gear such as river traffic and water pollution are continuing, and appear to be rapidly becoming more serious. Zhou & Li (1989) reported that the river traffic in the lower Yangtze has doubled every 10 years in the last 30 years, and that it will soon double again. Moreover, the handling capacity for cargo and passenger ships will be increased by 160% and 270%, respectively, to that of 1980, according to a 15-year expansion plan by the government. There are presently 221 ports along the Yangtze River, 37 of which can handle over one million tons of cargo a year. In the river section between Nantong and Wuhan, eight international ports were put into operation since 1982. The Yangtze River currently has a capacity of transport of over 0.12 billion tons of cargo and fifty million passengers per year, and this will be expanded more rapidly under the present governmental reform and open policy. There are presently sixteen bridges crossing the river, five more are under construction, and feasibility investigations of at least four others are underway. The value of the industrial and agricultural output in the area is about 40% of the nation's total. Waste water volume discharged into the Yangtze is about 15.6 billion cubic meters per year, of which about 12.3 billion cubic meters are industrial polluted waters. Approximately 80% of the waste waters are discharged directly into the environment without treatment. At the same time, banning of harmful fishing gear appears to be difficult or impossible to enforce.

Conservation strategy

The baiji is a heritage species deserving worldwide recognition. It is one of the nationally protected animals in China. The many and varied efforts of scientists, both Chinese and foreign, have started to receive the attention of government officers in China as well as international conservationists. In practice, however, it is very difficult to protect the species effectively. Several baiji rescue measures have been proposed and implemented since 1982. The following are the more important ones.

(1) Ex situ *conservation.* Semi-captive breeding of baiji in a safe area, such as a semi-natural reserve, is generally agreed as having the highest chance of success (Perrin *et al.*, 1987). The Tongling semi-natural reserve for baiji initiated by Zhou (1986) has taken shape in the lower reaches of the river after years of construction, and it is clear that it needs solid financial support for it to become appropriate to harbor baiji. A second semi-natural reserve is placed at Tian'ezhou, Hubei Province (Chen & Hua, 1989), where finless porpoises have apparently been thriving. A female baiji was live-captured and relocated into Tian'ezhou on 19 December 1995. However, the animal was found thin and dead on 22 June 1996. The difficulty of live capture is increasing and because baiji are becoming rare, they are now encountered very infrequently in the shallow waters suitable for capture. Concentration of manpower and resources to speed up semi-natural reserve projects are badly needed if the baiji is to persist.

(2) In situ *conservation.* The 135 km river section between Xintankou and Luoshan in the middle reaches of the Yangtze was selected to establish a protected area for baiji (Chen & Hua, 1989). An administrative agency in charge of local protection has been established. However, the agency is not in a position to reduce the rapid increase in vessel traffic, and it does not have sufficient resources to patrol the river section frequently. At the same time, according to our present estimate only about 6 baiji may inhabit this 100 km stretch of area at

any one time, and at least some of these will move between the 'protected' and adjacent areas. The effectiveness of this type of protection is therefore limited.

(3) *Research.* Much work has been done on several of the tasks outlined in the Proceedings of the Workshop on Biology and Conservation of the Platanistoid Dolphins held in 1986 (Perrin *et al.*, 1989). Population monitoring surveys are one of the fundamental parts of the conservation biology of baiji. The data reported in this paper have updated the population estimate for baiji. This in turn may help authorities to investigate conservation strategies and to speed up the semi-natural reserve projects. When working on the refinement of the recovery plan for the baiji, an important step should be a population and habitat viability analysis (PHVA) to determine what long-term effects the establishment of a semi-captive program and management have. The baiji PHVA will very much depend on population data and biological parameters of social structure and mating systems, all of which are scarcely known. Work with one captive dolphin in Wuhan has made some progress on collection of sperm, and studies on cryopreservation of semen are underway. Concentrations of organochlorines and heavy metals of existing tissue samples also need to be studied.

(4) *Public education.* Great effort has been made by our research group to raise the level of public awareness regarding the plight of baiji. Five thousand brochures and posters about conservation of the baiji were printed in 1990 with funds from the WWF International. Most were distributed to fishermen along the middle and lower reaches of the Yangtze River through the Fisheries Management Bureau in Hunan, Hubei, Jiangxi, Anhui and Jiangsu provinces. A 132-page book on the baiji dolphin (Zhou & Zhang, 1991) was released in Chinese and English and is being well received. Articles appealing for urgent action to save the baiji were published in a nation-wide newspaper and two journals (Zhou, 1989*b*, 1991, 1992). Widespread public education may well help save some baiji, but the overall trend of small and apparently decreasing numbers is not likely to be reversed by public awareness alone.

Potential impacts of the Three Gorges Dam

The international conservation community has expressed concern about the proposed giant Three Gorges Dam and the potential impacts such a project may have upon the baiji. Construction of this dam began in 1994 and the first generators are scheduled to begin operation in 2003, which will be the time that the project will begin to affect baiji and their habitats. An evaluation suggested that there would be three major adverse affects on the baiji after the dam is constructed and its associated reservoir is in place (Chen & Hua, 1987). The upper boundary of the baiji's distribution may move 200 km downstream to Ouchikou; the baiji's population size may decrease in a 130 km river section between Ouchikou and Chenglingji; and the incidental killings of baiji may increase in the river section below Chenglingji. These conclusions might be correct if the population size or density estimated in the present study could be maintained until the dam begins to operate. However, there is no doubt that the decline of the dolphin population will continue, even without the dam. Therefore, we consider it misleading to treat the Three Gorges Project as one of the imminent threats to the baiji. Attention should be focused on the semi-natural reserve projects and potential ways to save the species instead of the questionable impacts of the Three Gorges Project.

Acknowledgements

We thank Hua Yuanyu, who participated in the surveys in 1990; and Xu Xinrong for technical assistance in the field and laboratory; Zheng Bangyou, Zhang Xian and Feng Qingxuan for field assistance in May 1989; and Wang Yaming for comments on calculating the population size. We thank Alejandro Acevedo, Spencer Lynn and David Weller for critical reviews, and Ginger Barnett for typing. This research was funded by WWF International; the Bureau of Fisheries Management and Fishing Port Superintendence, Ministry of Agriculture, China; and the Whale and Dolphin Conservation Society.

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